

Optimizing Energy Management Strategy and Degree of Hybridization for a Hydrogen Fuel Cell SUV

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Previous work examined degree of hybridization on the fuel economy of a hybrid electric fuel cell sport utility vehicle. It was observed that not only was the vehicle control strategy important, but that its definition should be coupled with the component sizing process. Both degree of hybridization and the energy management strategy have been optimized simultaneously in this study. Simple mass scaling algorithms were employed to capture the effect of component and vehicle mass variations as a function of degree of hybridization. Additionally, the benefits of regenerative braking and power buffering have been maximized using optimization methods to determine appropriate battery pack sizing. Multiple optimization algorithms including both gradient and non-gradient based routines were used to quantify their effectiveness in solving the highly non-linear, and at times discontinuous, design space of a hybrid electric vehicle. The study highlighted the effects of the drive cycle demands of the optimal vehicle configuration and summarized the resulting design and behavior of these optimal vehicles on several worldwide driving schedules. Based on the analysis presented in this study we can make the following conclusions:

- Non-gradient based optimization tools can be quite effective in identifying the general location of optimal solutions but may require significant processing time to converge to the final global solution.
- The fuel cell hybrid vehicle study highlighted the fact that the design space is multi-modal including many locally optimal solutions.
- Optimal design of fuel cell hybrid vehicles will be highly dependent on the drive cycle and will be significantly influenced by any weighting factors included in the objective response.
- Although it is unlikely that there is one universal cycle or test procedure that will represent all driving conditions, in this study, the vehicle optimized for the NEDC cycle produced a vehicle that provided excellent off-cycle fuel economy performance.

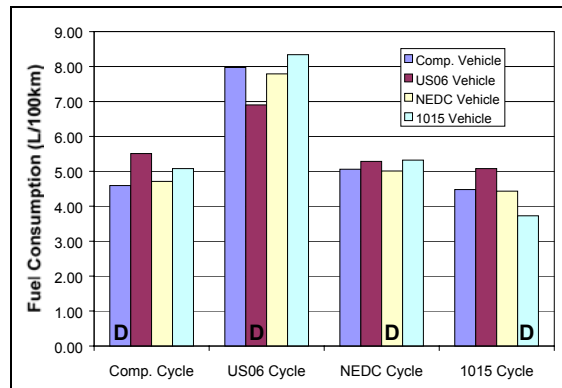


Figure 1: Variation of fuel consumption with drive cycle for 4 optimal vehicle designs

Figure 1 provides a summary of the fuel consumption results for the four resulting vehicles. In each case, the vehicle designed for the cycle out-performs the vehicles optimized for other cycles, clearly shown by the 'D' bar on the design-cycle results being lowest fuel consumption relative to the other 3 vehicles on that cycle.